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PRIMARY MICROBIOLOGICAL SUCCESSION ON A LANDSLIDE OF ALPINE ORIGIN AT MOUNT RAINIER

by

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In December 1963, immense masses of rock and debris broke loose from the north face of Little Tahoma Peak on the shoulder of Mount Rainier (Crandell and Fahnestock 1965).[1] Originating from a zone roughly 9,000 to 11,000 feet above sea level, the resulting series of avalanches swept down Emmons Glacier to deposit an estimated 14 million cubic yards of debris over 2 square miles of the glacier and the sparsely vegetated outwash valley below (fig. 1). Deposits reach thicknesses of about 100 feet in the valley, whose original elevation ranged from about 4,500 to 5,500 feet.

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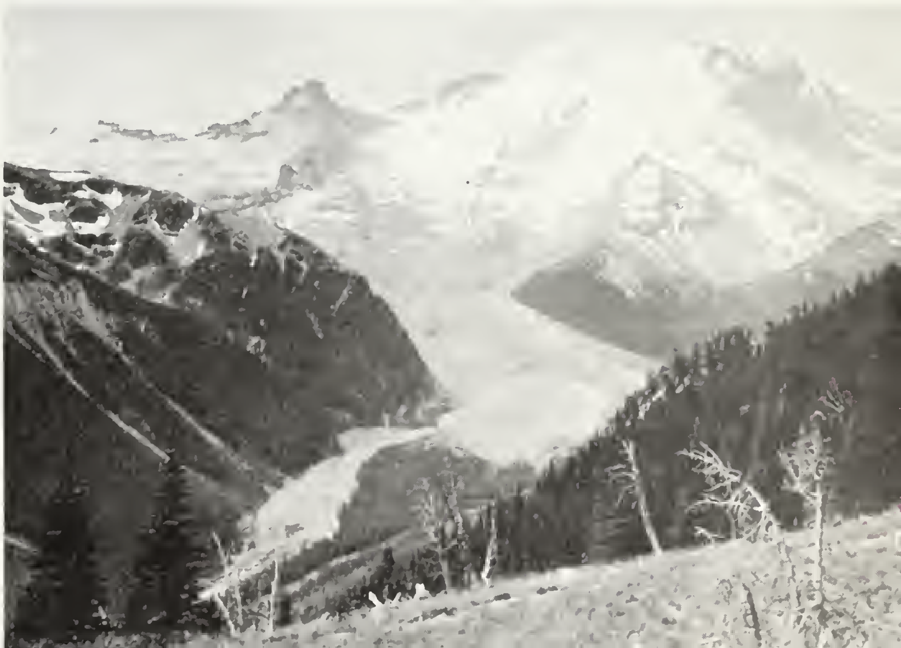

Figure 1.--Northeast slope of Mount Rainier with Little Tahoma Peak on left-center skyline and avalanche deposit in valley.

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[1] Names and dates in parentheses refer to Literature Cited, p. 7.

This nearly virgin, alpine "soil," laid in a valley surrounded by montane forest, presents superb opportunity for studies of soil development, plant succession, and distribution of pesticides and other environmental pollutants, especially when coupled with concurrent observations of nearby terminal moraines left from recent recession of Emmons Glacier. To seize this opportunity in time to observe early stages of microbiological succession, we began reconnaissance soil sampling and analysis in early October 1965.[2]

The top 8 inches of deposit were sampled at three locations: (1) near the middle of the lower half of the valley deposit (fig. 2); (2) at the lower edge of the main deposit, adjacent to uncovered moraine disgorged by Emmons Glacier in 1897 (Sigafoos and Hendricks 1961); and (3) on the 1897 moraine from under a clump of Sitka alder (*Alnus sinuata* (Reg.) Rydb.) adjacent to location 2 (fig. 3). In addition, water was sampled from a turbid pond trapped in a furrow on the deposit near location 1 (fig. 2). These locations were chosen to represent new deposits and older, plant-colonized surface. The extreme heterogeneity of both avalanche and moraine precluded any attempt to sample "average" conditions.

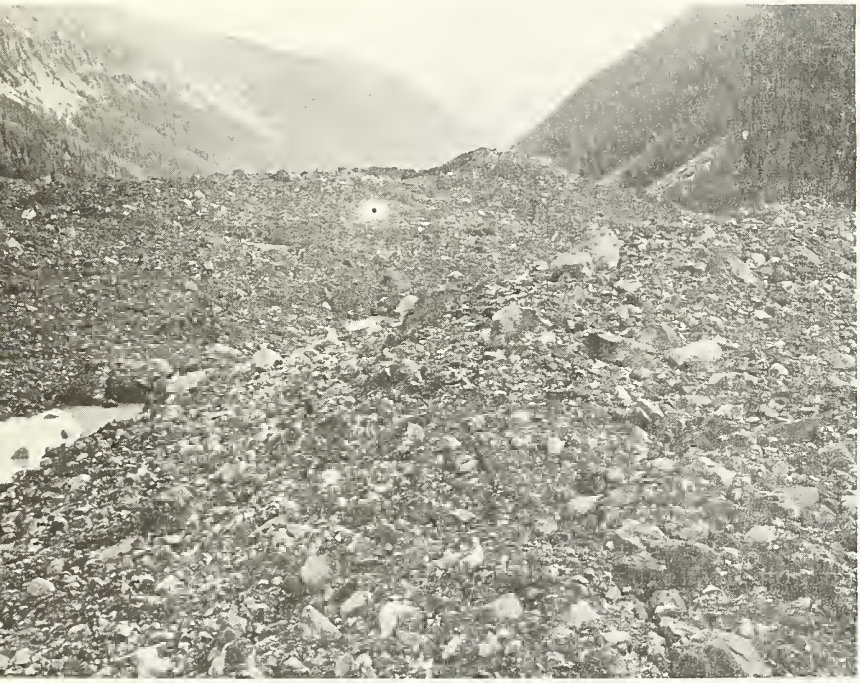

Figure 2.--Surface of the avalanche deposit with pond trapped in furrow.

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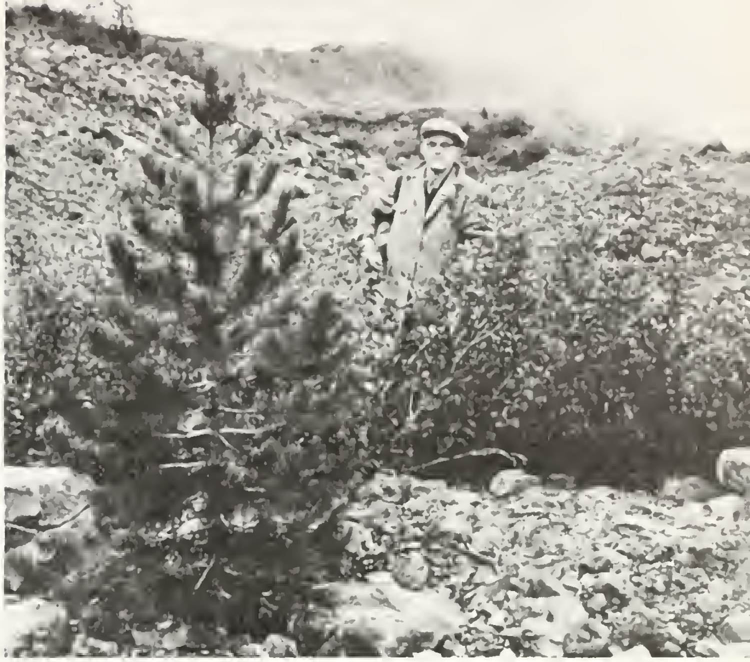
[2] We thank the staff of Mount Rainier National Park for facilities and assistance.

Figure 3.--Clump of *Alnus sinuata* on moraine adjacent to avalanche (sapling in foreground is *Pinus contorta* Dougl.).



Three collections of about 500 grams each were dug with sterile tools and combined at each location. After all stones thicker than 1 inch were discarded, each combined sample was sealed in a sterile bottle at the site. In the laboratory, 3 days later, samples were sieved with sterile precautions through a 10-mesh Tyler standard screen. Material larger than 10-mesh was dried, weighed, and discarded. After subsamples were taken for microbial analysis and determination of water content, pH, and ash, residuals were air-dried. Sample residuals from locations 1 and 3 were sieved through a series of closer meshed Tyler screens on a Porter sand shaker; fractions were weighed and then recombined (the 10-mesh residual from location 2 was insufficient for mechanical analysis). Finally, the recombined residuals and the residual from location 2 were ground to pass 100-mesh and analyzed for total carbon and nitrogen content.

Samples were dried to a constant weight at 105° C. to determine their water content. Glass-electrode determinations of pH were made with suspensions of one part soil in five parts water. Total nitrogen was determined by the Kjeldahl procedure, and total carbon by dry combustion at 950° C. For analysis of microflora, dilutions were prepared to provide 30 to 100 colonies per plate. Agar media included rose bengal and peptone-glucose-acid for molds, and sodium albuminate and trypticase soy for bacteria and *Streptomyces* (Martin 1950, Waksman and Fred 1922, Baltimore Biological Laboratory 1962).

A smaller proportion of avalanche material than moraine soil passed through the 10-mesh sieve (21 versus 63 percent), likely due to the differing origins of deposit. Though vegetation on the moraine doubtless has influenced breakdown of soil particles, studies of moraines in Alaska suggest that several more decades of plant growth must elapse before such effects become detectable (Crocker and Major 1955, Crocker and Dickson 1957, Viereck 1966).

In contrast to textural properties, chemical differences between avalanche and moraine deposits can reasonably be attributed to effects of vegetation on the moraine (table 1). Reaction of avalanche samples was near neutral, whereas the pond water had a pH of 8.2. Because the avalanche deposits are largely andesite (Crandell and Fahnestock 1965), a basic igneous rock, these relatively high pH's were expected. The moraine soil, though derived from similar rock, had a pH of 5.7. We ascribe this higher acidity largely to the deposit and decomposition of organic matter.

Table 1.--Chemical analyses of samples from deposits of Little Tahoma avalanche and adjacent moraine in percentage ovendry weight

Sample No.	Water	pH	Ash	Total carbon	Kjeldahl nitrogen	C:N ratio
	Percent		Percent	Percent	Percent	
1	10.5	7.2	98.9	0.075	0.002	38
2	8.7	7.2	99.8	.049	.002	25
3	7.0	5.7	99.4	.263	.014	19

Total carbon was minimal in the avalanche material. Carbon content of moraine samples, though low in comparison with well-developed soils (Buckman and Brady 1960), shows the contribution of organic matter from Sitka alder and its associated mosses and lichens. A notable amount of nitrogen had accumulated in the moraine soil. Some of this may have been contributed by free-living, nitrogen-fixing micro-organisms, but most can be reasonably attributed to the alder, a nodulated, nonleguminous woody plant capable of fixing atmospheric nitrogen. The concomitant lowering of the C:N ratio is particularly important for soil micro-organisms and plant succession. Sitka alder here influenced soil properties as it did on moraines in coastal Alaska (Crocker and Major 1955, Crocker and Dickson 1957) and as *Alnus rubra* did on forest soils of the Pacific Northwest (Tarrant and Miller 1963, Chen [3]).

Despite the interval of nearly 2 years between the avalanche and our sampling, the avalanche material still was at a very early stage of primary microbiological succession. Fungal populations (table 2) were analogous in both kind and number to those isolated from moraine soils in very early successional stages in coastal Alaska (Cooke and Lawrence 1959). Bacterial populations (table 3) were at levels similar to those of barren soils of the Arctic (Sushkina 1960). The profound influence of Sitka alder on microfloral populations was of a magnitude similar to that in Alaska (Cooke and Lawrence 1959).

Table 2.--Fungi isolated on dilution plates from samples of deposits of Little Tahoma avalanche and adjacent moraine in total number of colonies per ovendry gram of sample and proportion of various groups

Location No.	Medium[1]	Total colonies per gram	*Mucor* species	*Penicillium* species	*Aspergillus* species	Dematiaceae	Sterile mycelia	Other
		Number	Percent					
1	RB	300	1	6	0	4	43	46
	PGA	35	0	5	10	33	24	28
2	RB	160	0	50	0	0	6	44
	PGA	80	0	81	0	0	19	0
3	RB	56,000	0	93	0	0	0	7
	PGA	36,500	0	100	0	0	0	0

[1] RB = Martin's rose bengal-streptomycin agar, pH 7.0.

PGA = peptone-glucose-acid agar, pH 4.0.

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[3] Chen, Chi-Sin. Influence of interplanted and pure stands of red alder (*Alnus rubra* Bong.) on microbial and chemical characteristics of a coastal forest soil in the Douglas-fir region. 167 pp., illus. Unpublished Ph. D. thesis on file at Oreg. State Univ., Corvallis. 1965.

Table 3.--Bacteria isolated on dilution plates from samples of deposits of Little Tahoma avalanche and adjacent moraine in total number of colonies per ovendry gram of sample and proportion of *Streptomyces*

Location No.	Medium[1]	Total colonies per gram	*Streptomyces* species
		Number	Percent
1	Na Alb.	76,000	10
	TSA	24,500	0
2	Na Alb.	37,500	16
	TSA	214,000	0
3	Na Alb.	3,550,000	20
	TSA	5,900,000	12

[1] Na Alb. = sodium albuminate agar, pH 7.0.

TSA = trypticase soy agar (BBL), pH 7.0.

The low population of *Penicillia* and relative abundance of Dematiaceae at location 1 were unlike those for well-developed soils. The far greater population of fungi under alder on the moraine was characteristic of forest soils, as was the high proportion of *Penicillia* (Bollen and Wright 1961). Several other genera common to forest soils were lacking, however. We detected no fungi in water from the turbid pond.

Differences in bacterial populations similarly show the striking influence of alder. *Streptomyces* were relatively poorly represented in all cases, as compared with forest and arable soils where they frequently comprise nearly half the total count (Bollen and Wright 1961, Bollen 1941). The pond water had a very high count, 192,500 bacteria/milliliter (no *Streptomyces*). This large population was likely due to the high content of inorganic suspended solids, totaling 1,440 parts per million. No coliform bacteria were detected from inoculations of pond samples into lactose broth, so use of the area by animals has evidently remained low to date.

By August 1966, the avalanche deposit was still unstable, with considerable settling and slumping activity. Few vascular plants have become established, although current-year seedlings of *Alnus sinuata* and *Salix* spp. have taken tenuous hold in numerous locations. The ensuing sequence of microbiological succession will undoubtedly hinge on the same kind of soil amelioration that alder has exerted on adjacent moraine: accumulation of nitrogen and organic matter and lowering of the C:N ratio and pH.

LITERATURE CITED

Baltimore Biological Laboratory, Inc.
1962. Culture media and materials and apparatus for the microbiological laboratory. 244 pp. Baltimore, Md.

Bollen, W. B., and Wright, Ernest.
1961. Microbes and nitrates in soils from virgin and young-growth forests. Can. J. Microbiol. 7: 785-792.

Bollen, Walter B.
1941. Soil respiration studies on the decomposition of native organic matter. Iowa State Coll. J. Sci. 15: 353-374.

Buckman, Harry O., and Brady, Nyle C.
1960. The nature and properties of soils. Ed. 6, 567 pp., illus. New York: The Macmillan Co.

Cooke, W. B., and Lawrence, D. B.
1959. Soil mould fungi isolated from recently glaciated soils in south-eastern Alaska. J. Ecol. 47: 529-549.

Crandell, Dwight R., and Fahnestock, Robert K.
1965. Rockfalls and avalanches from Little Tahoma Peak on Mount Rainier Washington. U.S. Geol. Surv. Bull. 1221-A, 30 pp., illus.

Crocker, Robert L., and Dickson, B. A.
1957. Soil development on the recessional moraines of the Herbert and Mendenhall Glaciers, south-eastern Alaska. J. Ecol. 45: 169-185, illus.

__________ and Major, Jack.
1955. Soil development in relation to vegetation and surface age at Glacier Bay, Alaska. J. Ecol. 43: 427-448, illus.

Martin, James P.
1950. Use of acid, rose bengal, and streptomycin in the plate method for estimating soil fungi. Soil Sci. 69: 215-232, illus.

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Sigafoos, Robert S., and Hendricks, E. L.
1961. Botanical evidence of the modern history of Nisqually Glacier, Washington. U.S. Geol. Surv. Prof. Pap. 387-A: A1-A8, illus.

Sushkina, N. N.
1960. Characteristics of the microflora of Arctic soils. Soviet Soil Sci. 1960: 392-400.

Tarrant, Robert F., and Miller, Richard E.
1963. Accumulation of organic matter and soil nitrogen beneath a plantation of red alder and Douglas-fir. Soil Sci. Soc. Amer. Proc. 27: 231-234.

Viereck, Leslie A.
1966. Plant succession and soil development on gravel outwash of the Muldrow Glacier, Alaska. Ecol. Monogr. 36: 181-199, illus.

Waksman, S. A., and Fred, E. B.
1922. A tentative outline of the plate method for determining the number of microorganisms in the soil. Soil Sci. 14: 27-28.

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